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THE QUINCY (ILLINOIS) TYPHOID EPIDEMIC.*

EDWIN O. JORDAN AND ERNEST E. IRONS.

The city of Quincy is situated on the Mississippi River in the southwest part of Illinois about 100 miles above St. Louis. The population is nearly 37,000 (1900, 36,252; 1910, 36,587). In January, 1913, a sudden outbreak of typhoid fever occurred, involving approximately 200 bed cases. At the request of the city authorities an investigation of the epidemic was made by the writers early in February.

The usual record-cards were employed in the study of the outbreak, and full data regarding each patient were obtained wherever possible. In Quincy, as indeed in many American cities with 25,000–50,000 population, typhoid fever has not been a reportable disease, and at the beginning of our inquiry official records of cases were not available. Through the cordial co-operation of the Quincy physicians, however, a fairly complete list of bed cases was soon at our disposal.

There seems to have been little typhoid fever in Quincy between October 1 and December 25, 1912. We were able to obtain a history of several cases scattered along singly on the following dates: October 1, 7, 14, November 1, 24, December 1, 14, 15, and 18. On December 27 and 28, five cases developed, and from that time to about the first of February, new cases appeared daily. In all, we learned of 202 definite cases occurring in Quincy between December 27, 1912, and March 1, 1913.[1] We were able to secure quite complete information regarding 177 of this number. Except in a very few instances the patients had not been away from Quincy for at least 30 days before the onset of their illness. The cases comprised 99 males and 103 females. The age distribution was as follows:

Years	Cases
0–5	8
6–15	37
16–30	76
31–45	25
45 and over	12
No information	44
	202

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* Received for publication June 9, 1913.

[1] In addition we learned of three out-of-town cases, one fatal, attributable to infection in Quincy.

The approximate date at which the disease developed was obtained in 153 cases. The method of tabulation was the same as that used in our study of the Rockford typhoid epidemic in 1912.[1] So far as could be determined the date of onset as shown by the earliest symptoms was as follows, tabulating cases in six-day periods:

Period	Cases
January 1–6	11
" 7–12	29
" 13–18	42
" 19–24	35
" 25–30	29
" 31–February 5	7

This time distribution indicated the latter part of December and the first days of January as the probable period of maximum infection.

At Quincy as at Rockford[2] it was frequently difficult to determine the date of onset with any degree of exactness, owing to the attacks of typhoid fever having been preceded by an attack of gastro-enteritis. This complication is not uncommon in water-borne typhoid outbreaks. In some cases the enteritis is sufficiently severe to require the calling of a physician, and the patient remains more or less ill until the development of typical typhoid symptoms, it may be two or three weeks later. In others the attack of enteritis is slight and of short duration and the early typhoidal symptoms are attributed by the patient and his family to a simple recurrence of the original trouble. In the latter class of cases, a physician may not be called until the patient is in the second or third week of typhoid fever; in the former, a physician may be in attendance from the very beginning of the gastro-enteritis, two weeks or more before typical typhoid symptoms appear.

For these reasons some comment on the clinical features of epidemic typhoid seems worth while. In our studies of typhoid epidemics we have met with many cases in which the diagnosis was called in question because the disease presented clinical features which, though well recognized and often described, departed from the usual type of the disease. We were frequently met, too, with the objection that if the typhoid fever in a community was due to an infection of the general public water supply, typhoid fever should appear in a larger proportion of the population than was found to be the case.

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[1] *Jour. Infect. Dis.*, 1912, 11, p. 21.

[2] *Loc. cit.*

It is of course recognized that, of those individuals in a community who are exposed to typhoid fever through the infection of water, the number who suffer from typhoid fever may be relatively small. Thus in the Rockford epidemic, due to a sudden and temporary pollution of the water supply by sewage, the probable number of cases of initial enteritis was over 10,000 in a population of 50,000, but careful search for cases of typhoid revealed only about 200 cases. Out of a total of 46 persons residing in one block, 44 drank water within a few hours after the contamination occurred; 40 of these 44 persons drank sufficient water to produce gastro-intestinal disturbance, in some instances, mild with little or no diarrhea, in others, very severe with nausea, vomiting, purging, and marked prostration, and yet only one person of the 44 suffered from typhoid fever later. It is of interest that this person did not suffer from the initial enteritis. It might be assumed that the sharp enteritis with copious evacuations was the means of ridding the body of typhoid bacilli before they were able to gain a foothold, but among the typhoid cases about which we were able to obtain information, approximately 90 per cent had suffered from some gastro-intestinal disturbance within a few hours after drinking the infected water. They were then free for the most part from symptoms until the onset of typhoid prodromes some days later.

In those persons in whom typhoid fever follows the ingestion of typhoid bacilli, the severity of the disease may vary within wide limits, and if the presence of an epidemic is not recognized, many mild cases pass without the diagnosis of typhoid being made. In both the Quincy and the Rockford epidemics we met with certain mild cases in which the fever was very slight, with moderate malaise, and headache, and in which a positive diagnosis was made only from examination of the blood or confirmed by the finding of *B. typhosus* in the stools. Other cases were seen in which the fever was moderate in degree (100–101° F.) with a duration of but 10 or 12 days and with practically no prostration nor malaise. In some of these there was definite enlargement of the spleen and sometimes a profuse crop of rose spots. In the absence of a recognized epidemic some of these patients would not have consulted a physician, but would have attributed their indisposition to "colds," errors in diet, and the like.

Typhoid fever in the aged is particularly likely to be atypical, and pneumonia is well recognized as a frequent complication. In the Quincy epidemic, as will be noted later, there were an unusual number of cases diagnosed "influenza," "pneumonia," and "intestinal grippe" during the period of the epidemic, in an institution containing some 1,500 persons over 60 years of age. In no case was a clinical diagnosis of typhoid fever made, nor were the symptoms of illness of such a character to suggest such a diagnosis. Yet the water supply of this institution and of the city at large were the same, and the relatively high death-rate from the above diseases as compared with that of corresponding months in previous years in this institution, occurred at the same time as did the period of initial enteritis followed by typhoid in the city. It is of course probable that many of these cases of "influenza" were infections due to the polluted water ingested at the outset of the period of polluted water supply. A high death-rate, however, from pneumonia and influenza and severe gastro-intestinal disturbance continued long after the enteritis in the city had ceased; so that it seems probable that certain of these deaths were due to typhoid infection although not recognized as such.

Another factor that tends to obscure the diagnosis of typhoid fever in such epidemics is the recurrent character of many of the cases of the initial enteritis. In the Rockford epidemic the initial pollution of the water supply began and ceased abruptly and the maximum degree of pollution lasted only a few hours. A very large proportion of the population suffered from enteritis within 48 hours after the beginning of the pollution of the water. In the majority of the cases the enteritis subsided within a few days to a week. In about one-fourth of the cases, however, there were recurrences of diarrheal symptoms at intervals of three to five days with intervening periods of relative freedom from gastro-intestinal disturbance; as many as three or four of such recurrences were noted in some cases. So, when the typhoid cases began to develop about two weeks after the initial infection, there were still some cases of recurrent enteritis in the practice of many of the physicians. Some physicians recognized clearly the presence of an epidemic and that some of the cases were typhoid fever and others recurrent enteritis. In the minds of others, however, the occurrence of the two types of the disease was very confusing, and, because the typhoid patients did not present the severe and typical forms of typhoid fever, the diagnosis of "abdominal grippe," "influenza," etc., was made in both forms of illness.

As has been pointed out in both these epidemics, we had to deal with two types of infection: the initial infection due to the pollution of the water supply with sewage, followed within ten days or two weeks by an epidemic of typhoid. It is undoubtedly true that in many instances the initial enteritis modified the development of subsequent typhoid fever, but quite apart from this influence the variation in the symptomatology in the typhoid cases has been much greater, with more mild and scarcely recognizable cases on the one hand and more severely toxic cases with high fever and delirium presenting the typical typhoid state on the other, than has been the case in epidemics originating in an infected milk supply.[1] The relative mildness and greater uniformity in type in milk epidemics of typhoid fever have been pointed out by other observers, but this difference has been so striking in the series of epidemics which we have studied that the point has seemed worthy of reiteration.

There were 16 deaths from typhoid fever in Quincy during the period covered by our inquiry. The deaths occurred on the following days: January 20, 25, 30, 31, February 4, 8 (2), 9, 10, 12, 13, 20, 21, 26, March 8, 13. Distribution of deaths according to age and sex was as follows:

Sex	Age	Cases	Deaths	Percentage
Male	0–19	39	2	5
Female	0–19	29	3	10
Male	20+	41	9	22
Female	20+	49	2	4

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[1] Jordan and Irons, *Jour. Amer. Med. Assn.*, 1912, 63, p. 169.

At Quincy as at Rockford[1] the case-mortality among adult males was considerably higher than among males under 20.

As will appear presently, typhoid infection probably occurred in Quincy to a greater or less degree for at least two weeks, possibly for a longer period, so that it was not possible to make any sharp distinction between primary and secondary cases. There were in all: 177 one-case families; 9 two-case families; 3 three-case families. In seven cases the evidence of contact infection was practically conclusive and in at least as many more it was highly probable.

In an epidemic presenting the features described, and occurring in winter, fly-borne infection may be excluded. Personal contact, although responsible for some cases, could not cause so explosive and widespread an outbreak as this.

Data were collected so far as possible concerning the character of the milk supply. The records showed that 55 different milk-dealers supplied families in which typhoid had developed, that 15 patients had used condensed milk only, five had used a particular brand of canned cream, and eight had used no milk of any sort. In no instance so far as ascertained did the number of cases on any particular milk route bear a disproportionate ratio to the number of customers on that route. There was hence no reason to believe that the milk supply was responsible for the outbreak.

On the other hand, it was found that in all those cases regarding which information could be obtained, the city water was used constantly or occasionally. This factor was not lacking in any instance we investigated. In a number of families using well or cistern or bottled water, or boiled city water, all the members were exempt save those that drank city water at school or at their place of business.

The events preceding the typhoid outbreak are also suggestive of water infection. From about December 20 to the 5th or 6th of January many cases of the so-called "intestinal grippe" or "winter cholera" occurred in Quincy. According to information kindly furnished us by many physicians, these cases of "winter cholera" were very numerous and quite uniformly distributed through the city. About December 28–January 4, this affliction was so widespread that it was generally commented on in the Quincy newspapers. During the same period the appearance of city water as drawn from the taps was such as to excite criticism in the daily press. One paper declared (December 31) that "boiling the water is much better than suffering all the various forms of stomach trouble which the doctors report in Quincy." And again: "Rarely if ever before have there been so many cases of the plague." Another paper (January 4) speaks of "nine out of every ten people in the city" as being affected with the "intestinal grippe."

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[1] *Op. cit.*, p. 23.

This outbreak of enteritis was followed in from 10–20 days by a number of cases of typhoid fever. Allowing for the usual period of incubation of typhoid fever, this brings the date when the typhoid infection took place in exactly the same period with the enteritis infection.

It is thus clear that two outbreaks of disease occurred in Quincy in December, January and February—one, the enteritis with a short period of incubation, and the other, typhoid fever, following after a longer interval. This is no novel or unusual occurrence. Precisely similar outbreaks have been observed in Mankato, Minn.,[1] Rockford, Ill.,[2] and other places. An outbreak of gastro-enteritis and typhoid fever due to drinking-water obtained from the Mississippi River by excursionists on the steamer "G. W. Hill" occurred in July and August, 1912, and has been described in *Public Health Report No. 104* of the U.S. Public Health Service.

Conditions at the Soldiers' and Sailors' Home in Quincy with about 1,500 residents were particularly interesting. The average age of the residents is 71, the youngest being 60. From information kindly furnished by Dr. Ehle and others it appears that, while there were no cases of diagnosed typhoid fever in the period in question, there were hundreds of cases of diarrhea in December and particularly in early January. The advanced age of the patients undoubtedly influenced the course of the disease and also the diagnosis. It is worth noting that in January, 1913, seven deaths were recorded from "influenza," "enteritis," and "acute gastritis," whereas practically no deaths had been recorded from these causes immediately prior to this outbreak or at this period in previous years.

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[1] *Jour. Infect. Dis.*, 1911, 9, p. 710.

[2] *Ibid.*, 1912, 11, p. 21.

There is reason to believe that the public water supply has played in the past a large part in the causation of typhoid in Quincy. While it is unfortunate that there has been practically no registration of typhoid cases, the board of health possesses excellent mortuary records. From a compilation made from them by Mr. W. R. Gelston, the average number of typhoid deaths reported annually per 100,000 population was as follows:

1870–1879	132
1885–1889	105
1890–1899	63[1]
1900–1909	36

During the past four years the rates have been as follows:

Year	Deaths	Death-Rate per 100,000
1909	16	44
1910	10*	27
1911	8	22
1912	6	16

* Including one death from "paratyphoid fever."

The seasonal distribution of deaths is especially significant. In the four years, 1909–12, the deaths in 3-month periods are as follows:

December–February	14
March–May	11
June–August	7
September–November	8

These figures show a larger number of deaths in the winter and early spring months than in summer and autumn. This is a reversal of the usual seasonal distribution observed in cities with an uncontaminated water supply where, as is well known, typhoid is more prevalent in late summer and early autumn than at other times of the year. The excessive number of typhoid deaths in Quincy in winter and spring is evidence that some part has been played in the past four years by water infection. It may be noted especially that in 1912 there were only two deaths recorded between

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[1] Filter plant built in 1891.

May 1 and December 31—the smallest number of deaths reported in a similar period during the four years in question. The reason for this will appear presently.

All the evidence obtainable from a study of the cases pointed to the responsibility of the public water supply: the explosive character of the outbreak; the age distribution of the cases; the absence of evidence implicating the milk supply or any other article of food; the coincidence between the widespread outbreak of "winter cholera" and the date when the typhoid infection must have occurred; the distribution of cases in correspondence with the density of population and the location of the water mains, and the fact that in the past four years typhoid fever has been more prevalent in Quincy in winter and spring than in summer and autumn.

The conditions surrounding the Quincy water supply may be briefly described.[1] The water is obtained from the Mississippi River through an intake pipe extending about 1,400 feet from the suction well at the pumping-station to a point in the Mississippi River a short distance south and west of the point of land marking the entrance to Quincy Bay (see diagram). "The intake pipe is 30″ in diameter and with the exception of some 75′ or 80′ of iron pipe extending from the suction well, it is made up of wooden staves with bands around the staves to hold them in place. It ends in an intake crib weighted down to the bottom of the river with stone. In the crib is a cast iron pipe in a vertical position, which rises to a height sufficient to prevent the intake pipe from filling up with sand." The dangerous position of the intake pipe may be noted on the accompanying diagram. The Broadway sewer, one of the largest of the main city sewers, empties into the river two blocks north of the pumping-station. During the early part of February, 1913, we observed that the flow of the warm water from this sewer was sufficient to keep unfrozen a stretch of the river extending some 20 or more feet from the shore. This flow from the sewer passes directly over the intake pipe, and the old wooden intake pipe is thus bathed a good deal of the time with fresh sewage. In case even small leaks exist in the pipe, the danger is obvious. In May, 1912, a leak in the intake pipe due to a broken or bent stave was

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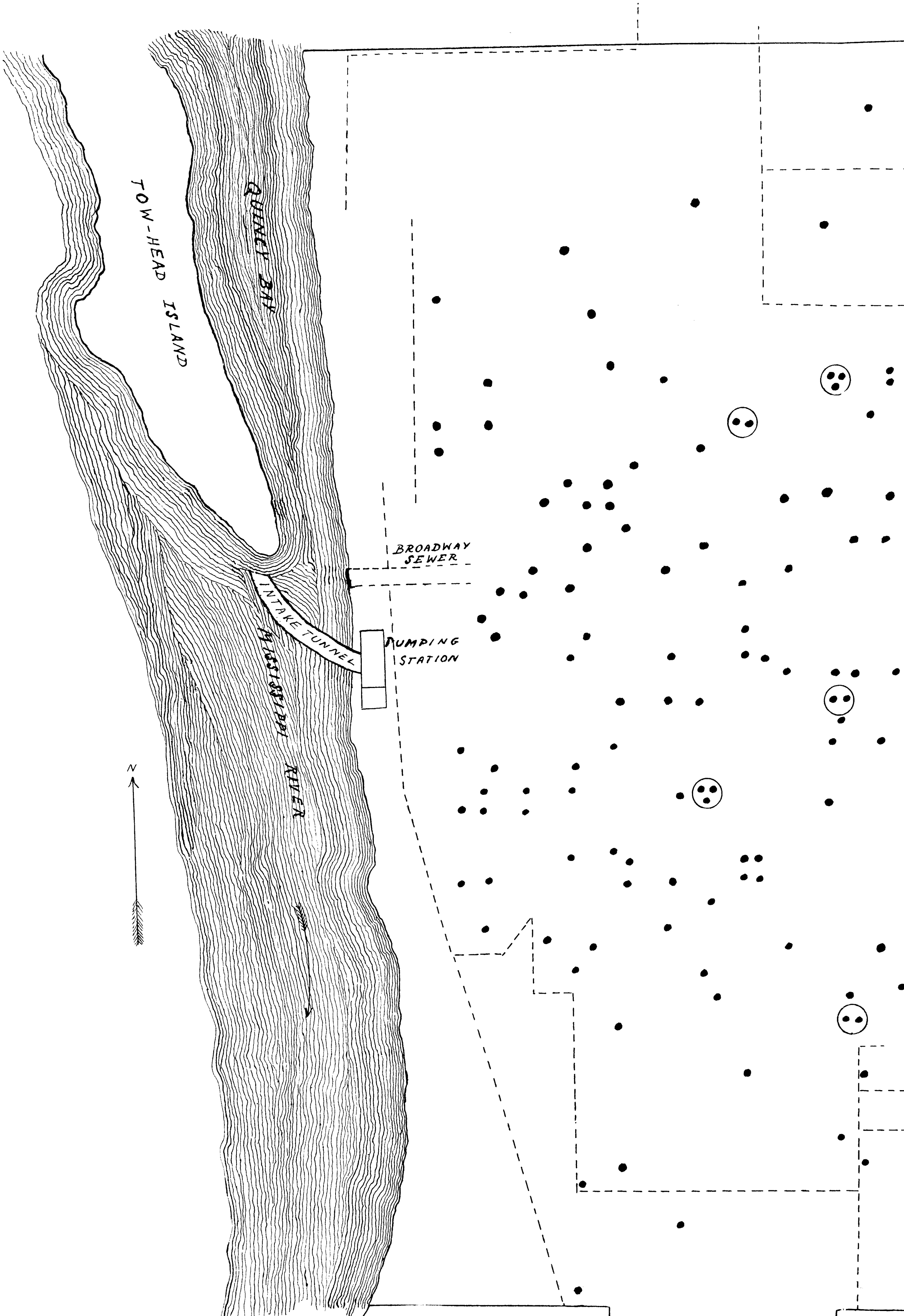
[1] The description is in part taken from personal observation, in part from a report, *On the Plant of the Citizens Water Works Co.*, made to the City Council of Quincy by Mr. C. A. Jennings in February, 1912.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PUMPING STATION
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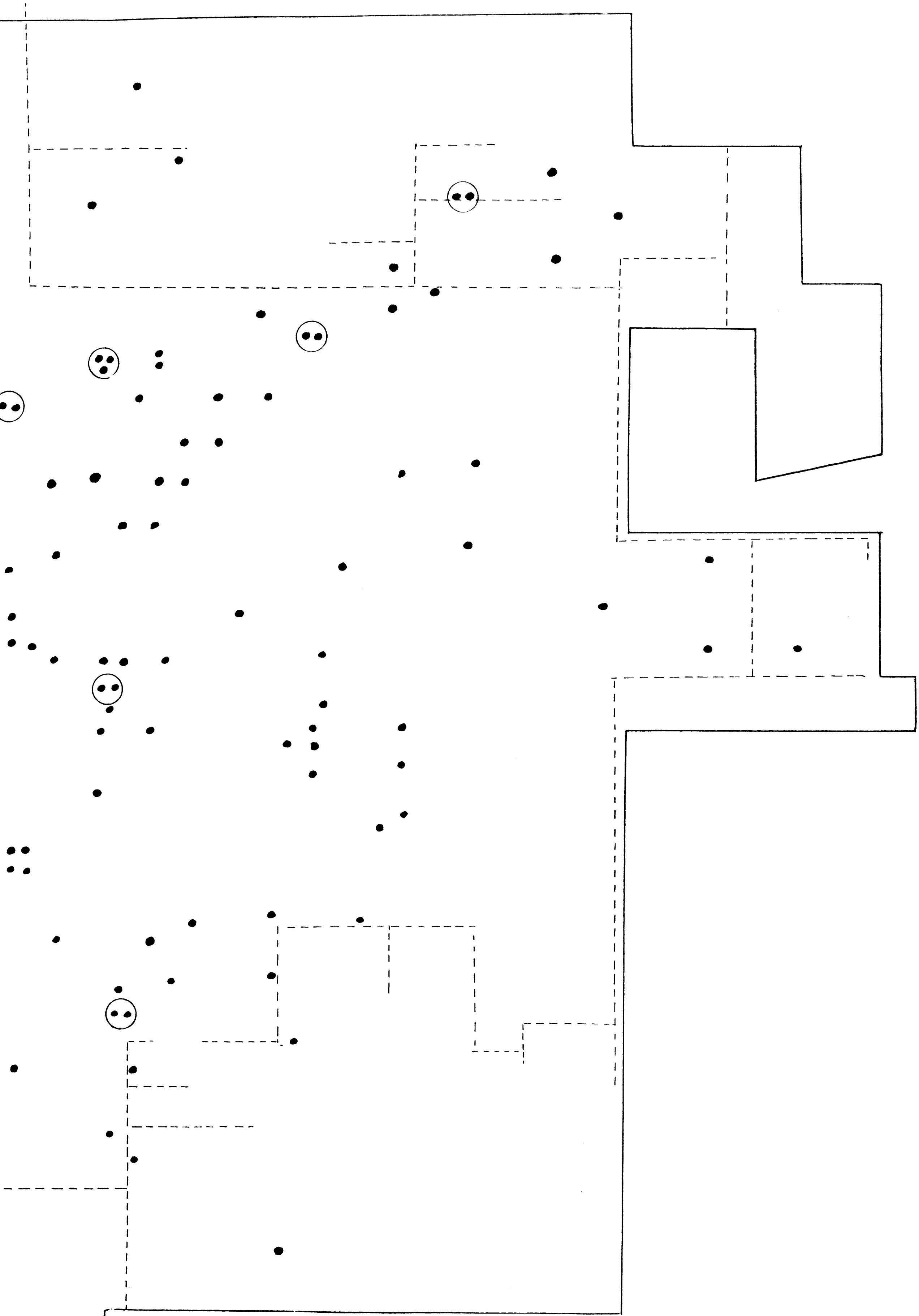


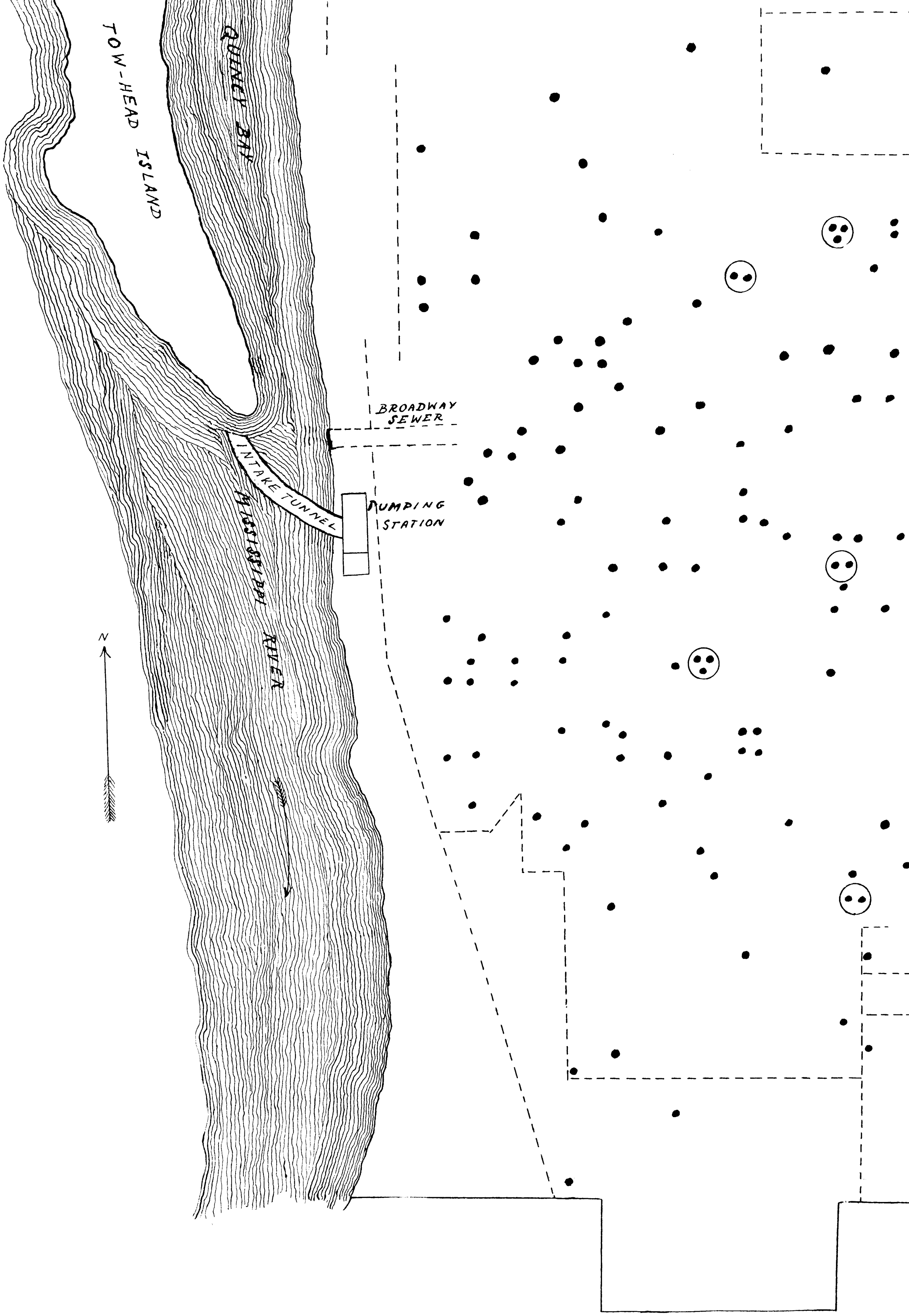
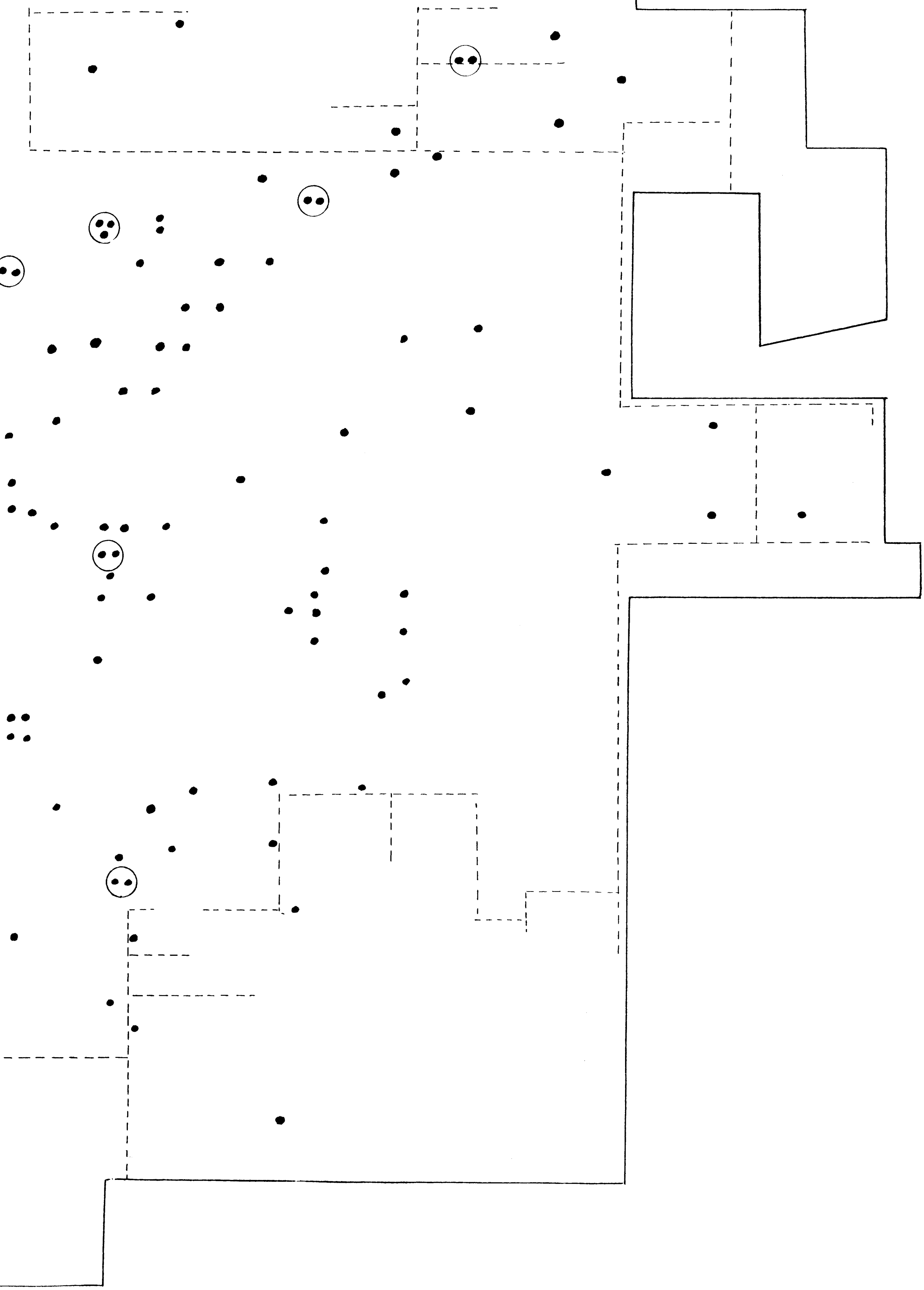


Fig. 1.—Diagram showing location of water works and distribution of typh
Illinois. Full lines represent city limits. Broken line represents the approximate
public water supply. Each black dot shows the location of a case of typhoid.



orks and distribution of typhoid cases, Quincy, ne represents the approximate boundaries of the tion of a case of typhoid.

repaired by a diver employed for the purpose. Whether the pipe is now bacteriologically tight or not seems to be uncertain. At the time of our visit to Quincy it was impracticable to test the pipes for leaks owing to the ice on the river. Some bacterial observations made by Gelston in 1911 (cited in Jennings' report) and by Jennings in 1912 indicated an increase in the number of bacteria between the intake crib and the suction well. Whether the water at the intake crib is liable at times to sewage contamination from the Broadway sewer is a matter which would require a special and detailed investigation to determine. It seems possible, however, that a rapid change in the river level might cause deflection of some of the sewage toward the intake. It may be added also that the sewage from the Soldiers' Home and from some other places enters Quincy Bay above the point mentioned. The actual extent to which the intake is exposed to danger from these contaminating sources has never been fully investigated.

The water flows by gravity into the intake pipe, then by gravity into the suction well. There is no pipe directly connecting the intake pipe and the pump suction. The water discharges from the intake pipe into the suction well, the water level in it being the same as that in the river while the low-duty pump is not operating. From the suction well the water is pumped to a settling-basin which is far too small for efficiency, since it provides for a subsidence period of only little more than an hour. Sulfate of aluminum is used as a coagulant. The water then flows from the basin to a series of filters and thence to the high-duty pump. The surplus of water not drawn from the mains passes into a storage reservoir on high land to the northeast of the city.

The filters, 14 in number, are of the O. H. Jewell type and were installed about 20 years ago. They are circular wooden tanks, 12 inches in diameter, and are arranged in the filter house in two rows of five each and one row of four tanks. These filters are of the mechanical or gravity type and were designed to operate at a normal rate of filtration of about 125,000,000 gallons of water per acre of sand area per day of 24 hours. Each filter has an area of 113.1 square feet and at the normal rate of filtration will produce 13,504 gallons per hour or 324,104 gallons per 24 hours, no allowance being made for time out of service while being washed or cleaned and prepared for operation after cleaning. It has been known for some years that the bacterial efficiency of these filters was low.[1] Jennings has shown that "the average percentage removal of bacteria for the period October, 1911, to February 9, 1912, inclusive, by the filters was only 86.2 per cent, with a minimum of 54.6 per cent and a maximum removal of 98.5 per cent." In view of this very unsatisfactory condition of the filtration plant, treatment of the water with bleaching powder was suggested as a safeguard. Bleach was accordingly added to the water in various amounts on the following dates:

Year				
1909	April	14–April	27	inclusive
	May	4–June	9	"
	June	24–June	25	"
	July	6–August	5	"
	August	24–August	27	"
	October	11–November	8	"
	November	30–December	1	"
1910	February	14–February	15	"
	March	10–March	21	"
	March	23–May	26	"
1912	March	25–December	31	"
1913	January	3 to date		

There is ground for believing that the use of the calcium hypochlorite has been efficacious in some degree in preventing typhoid fever. The year 1912 during which the hypochlorite treatment was used for about nine months, had the lowest typhoid death-rate recorded in Quincy. From May 1 to December 15, 1912, only one death from typhoid fever was reported, a record unequaled in the sanitary history of the city. The coincidence is worth noting also that the next longest period of continuous hypochlorite treatment, March 23 to May 26, 1910, is followed by four months, April, May, June, and July, of complete exemption from typhoid fever deaths.

There is no doubt that the raw river water entering the intake well of the pumping-station is at times rich in bacteria. An examination in May, 1911, showed an average of 20,520 per cubic centimeter, and Jennings found as many as 174,000 on February 7, 1912. Through the kindness of Mr. Gelston, we were able to examine the data of analyses made by him in 1912–13. The following table (Table 1) gives the average and range for four months.

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[1] W. R. Gelston, "Bleaching Powder as an Adjunct to Filtration at Quincy, Ill.," *Proc. Second Meeting of Illinois Water Supply Association*, 1910, p. 193.

TABLE 1.

1 C.C. COLONY COUNT (AGAR, 37° C.)

	INTAKE WELL			SETTLING BASIN			CLEAR WELL OR HIGH-PRESSURE PUMP		
	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum
1912 Oct.....	87,900	1,000,000	1,700	16,000	100,000	100	470	4,000	12
Nov....	6,900	33,750	630	5,200	30,000	190	40	208	8
Dec.....	2,000	9,950	250	1,500	3,250	240	140	402	21
1913 Jan.....	6,400	112,500	165	1,800	50,000	110	350	702	20

GAS-PRODUCING BACTERIA 1 C.C. (DEXTROSE BROTH).

	INTAKE WELL	SETTLING BASIN	CLEAR WELL OR HIGH-PRESSURE PUMP	HYPOCHLORITE AVAILABLE CHLORIN, PTS. PER MILLION		
	Percentage Positive	Percentage Positive	Percentage Positive	Average	Maximum	Minimum
1912 Oct..............	39	88	18	0.44	0.58	0.31
Nov..............	68	82	33	0.44	0.60	0.18
Dec..............	74	90	76	0.15	0.30	0.07
1913 Jan..............	93*	79*	29*	0.44	0.96	0.00

* Lactose bile.

It will be noted: (1) that the raw water has at times a very high bacterial content; (2) that gas-producing bacteria are abundant; (3) that the percentage reduction both of bacteria growing on agar at 37° and of gas-producing bacteria was much less in December than in the other months; and (4) that the average amount of hypochlorite added to the water in December was much lower than in any other month. It should be observed especially that so far as hypochlorite dosage is concerned, the first few days of January belong with the December period. No bleach at all was added on January 1 and 2 and but 0.25 and 0.35 on January 3 and 4, respectively. Water samples from the high-pressure pump on the first five days of January showed the presence of gas-producers in all tests (1 c.c.) and a percentage reduction compared with the intake well on the same days of only 61 (January 3) and 62 (January 1) per cent. On January 3, 702 colonies growing on agar at 37° C. were obtained in the water from the pressure pump.

Through a large part of the month of December, therefore, the amount of hypochlorite added to the water was not sufficient to bring about the degree of bacterial reduction usually considered requisite in treatment of water of this character. Many bacteria from the originally dangerously contaminated water were apparently able to pass through unscathed into the mains during this period.

The few bacterial examinations[1] that we were able to make during our stay at Quincy, February 3–13, showed that the water in the intake well during that period had a high bacterial content—140 to 665 colonies per cubic centimeter at 37° and 235 to 10,440 at 20°. Colon bacilli were found in every one of twenty $\frac{1}{8}$ c.c. samples examined February 10. During the same period the bacterial content of water samples collected from the high-pressure pump and from taps in various parts of the city ranged from 11 to 55 at 37° and 16 to 101 at 20°. Gas-producing bacteria were present in the proportion of 10 in 50 c.c. of the water (lactose broth). During this period the hypochlorite added to the water averaged 0.54 with a minimum of 0.40 (available chlorin, pts. per million).

SUMMARY AND CONCLUSIONS.

1. The Quincy typhoid epidemic occurring in January and February, 1913, included about 200 bed cases—a case-rate of about 1 in 180 of the population.
2. No evidence could be found that milk supply was in any degree concerned in the outbreak; fly infection and some other factors could be definitely excluded.
3. The epidemiological features of the outbreak pointed to water supply infection.
4. The Quincy water supply is taken from the Mississippi River and is dangerously exposed to contamination with fresh sewage from one of the city's own sewers.
5. Bacterial examination of water samples from the intake well

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[1] The water examinations were made for us by Mr. A. H. Hixson, who also aided us in securing data respecting some of the typhoid fever cases.

of the Quincy Water Works has given in the past and still gives unmistakable evidence of gross contamination.

6. The present rapid filter system is entirely inadequate to free this raw water from dangerous bacteria.

7. There is evidence that the bleaching powder which was added to the water before its entrance into the mains from March 25 to December 1, 1913, prevented water-borne typhoid fever from reaching its usual prevalence in Quincy during this period.

8. The amount of bleach added in December, 1912, and the first few days of January, 1913, was much below the average for the preceding eight months. This reduction in the percentage of hypochlorite permitted sewage bacteria to pass through unharmed into the water mains.

9. The period during which an insufficient amount of hypochlorite was used corresponds with the date when the maximum typhoid fever infection occurred and also with the date of an extensive outbreak of gastro-enteritis.

10. The resumption early in January of adequate hypochlorite treatment was followed by the immediate subsiding of the epidemic.